CS412 - Project Plan
Image Registration

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1 Introduction

This project involved stitching images together to create panoramas. We concerns the problem of fully automated panoramic image stitching from a collection of overlapping and similar pictures. In this work, we consider existed image-stiching algorithms and OpenCV's sources which are well studied and are shown that effective to process images. We selected the best algorithmes and then build an application creating panoramas. We used invariant local features to find matches between all of the images, which is adaptable to problems of ordering, orientation, scale and illumination of the input images.

2 Project Details

2.1 Theory

Image stitching is the process of combining multiple images with overlapping fields of view to create a segmented panorama or high-resolution image.

General overview of image stitching algorithm:

Firstly algorithms are needed to determine the appropriate mathematical model relating pixel coordinates in one image to pixel coordinates in another. This is for image alignment.

Next, we need to estimate the correct alignments relating various pairs (or collections) of images. Algorithms that combine direct pixel-to-pixel comparisons with gradient descent (and other optimization techniques) can be used to estimate these parameters.

Distinctive features can be found in each image and then efficiently matched to rapidly establish correspondences between pairs of images. When multiple images exist in a panorama, techniques have been developed to compute a globally consistent set of alignments and to efficiently discover which images overlap one another.

For image stitching, we must first decide on a final compositing surface onto which to warp or projectively transform and place all of the aligned images. We also need to develop algorithms to seamlessly blend the overlapping images, even in the presence of parallax, lens distortion, scene motion, and exposure differences.

Keypoint detection: Feature detection is necessary to automatically find correspondences between images. Robust correspondences are required in order to estimate the necessary transformation to align an image with the image it is being composted on. Corners, blobs, harris corners and Difference of gaussian of harris corners (DoG) are good features since they are repeatable and distinct. SIFT and SURF are recent keypoint or interest point detector algorithms but a point to note is that these are patented and their commercial usage restricted. Once a feature has been detected then a descriptor method like SIFT descriptor can be applied to later match them.

The image stitching process can be divided into three main components: image registration, calibration and blending.

- Image registration involves matching features in a set of images or using direct alignment methods to search for image alignments that minimize the sum of absolute differences between overlapping pixels. When using direct alignment methods one might first calibrate ones image to get better results. To estimate a robust model from the data, a common method used is known as RANSAC The name RANSAC is an abbreviation for "RANdom SAmple Consensus". It is an iterative method for robust parameter estimation to fit mathematical models from sets of observed data points which may contain outliers. The algorithm is non-deterministic in the sense that it produces a reasonable result only with a certain probability, with this probability increasing

as more iterations are performed. The basic assumption of the method is that the data consists of "inliers", i.e., data whose distribution can be explained by some mathematical model, and "outliers" which are data that do not fit the model. Outliers are considered points which come from noise, erroneous measurements, or simply incorrect data. For the problem of homography estimation, RANSAC works by trying to fit several models using some of the point pairs and then checking if the models were able to relate most of the points. The best model, i.e., the homography which produces the highest number of correct matches, is then chosen as the answer for the problem thus if the ratio of number of outliers to data points is very low the RANSAC outputs a decent model fitting the data.

- Image calibration aims to minimize differences between an ideal lens models and the camera-lens combination that was used. Alignment may be necessary to transform an image to match the view point of the image it is being composted with. Alignment in simple terms is a change in the coordinates system so that it adopts a new coordinate system which outputs image matching the required viewpoint. Projective transformation is the farthest an image can transform (in the set of two dimensional planar transformations) where only visible features that are preserved in the transformed image are straight lines whereas parallelism is maintained in an affine transform. Projective transformation can be mathematically described as x = H * x Where x is points in the old coordinate system, x is the corresponding points in the transformed image and H is the homography matrix.

- Image blending involves executing the adjustments figured out in the calibration stage, combined with remapping of the images to an output projection. Colors are adjusted between images to compensate for exposure differences. If applicable, high dynamic range merging is done along with motion compensation and deghosting. Images are blended together and seam line adjustment is done to minimize the visibility of seams between images. If applicable, high dynamic range merging is done along with motion compensation and deghosting. Images are blended together and seam line adjustment is done to minimize the visibility of seams between images.

2.2   Methodology

Algorithm: Automatic Panorama Stitching

Input: n unordered images
I. Extract SIFT features from all n images
II. Find k nearest-neighbours for each feature using a k-d tree
III. For each image:
(i) Select m candidate matching images that have the most feature matches to this image
(ii) Find geometrically consistent feature matches using RANSAC to solve for the homography between pairs of images
(iii) Verify image matches using a probabilistic model
IV. Find connected components of image matches
V. For each connected component:
(i) Perform bundle adjustment to solve for the rotation 1, 2, 3 and focal length f of all cameras
(ii) Render panorama using multi-band blending
Output: Panoramic image(s)

2.3   Data, Scenarios, and Models

2.3.1   Data

Photographic images with overlapping fields of view

2.3.2   Models

Probabilistic model for image match verification: to compare probability that this set of RANSAC inliers/outliers was generated by a correct/false image match:

$$\frac{B(n_i; n_f, p_1)}{B(n_i; n_f, p_0)} \overset{accept}{\underset{reject}{\gtrless}} \frac{1}{\frac{1}{p_{min}} - 1}$$

- ni = inliers, nf = features

- p1 = p(inlier — match), p0 = p(inlier — match)

- pmin = acceptance probability

2.4   Time plan for project

- Week 1, 2: Understanding the paper and related notions

- Week 3, 4, 5: Implementing the algorithm

- Week 6: Testing

References

http://matthewalunbrown.com/papers/ijcv2007.pdfg